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DRAWINGS ATTACHED

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(54) IMPROVEMENTS RELATING TO MULTI-STAGE RADIAL FLOW COMPRESSORS

(71) We, BROWN BOVERI - SULZER TURBOMACHINERY LIMITED, a Company organised under the Laws of Switzerland, of 8005 Zurich, Hardstrasse 319, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to multi-stage radial flow compressors and is particularly, although not exclusively, applicable to such compressors for high pressures and with horizontally disposed shafts.

Assembling multi-stage radial flow compressors is rendered difficult because diffuser rings and stationary flow deflecting elements must be disposed between the individual impellers. It is necessary either for unidivided diffuser rings and flow deflecting elements to be slid on to the shaft between the impellers when these are slid on to the shaft or, in the case of axially divided diffuser rings and flow deflecting elements, for one half of each diffuser ring and flow deflecting element to be inserted from one side between two impellers after these have been slid on to the shaft and then for the other half of each diffuser ring and flow deflecting element to be inserted from the other side, whereupon both halves are joined to each other by means of bolts. Prior to installation into the casing the flow elements disposed between the impellers are supported on the rotor only by means of the seals between these elements and the shaft. An assembly of this kind is then inserted into the casing, there being a risk of damaging the seals by engagement between the flow deflecting elements and the impellers. Thereafter the covers are brought over the shaft ends at the ends of the casing and are secured thereon. This is followed by the shaft seal housings being inserted at both ends of the machine from the outside into recesses in the covers. Finally, the bearings must be moved over the shaft ends at both ends and must be mounted on the casing. Only then will the impellers have a precisely defined central position within the flow deflecting elements so that the seals disposed therebetween have no further physical contact with such elements. This means that during the entire assembling procedure there is a serious risk of damage to the mechanically sensitive parts of the seals—for example the labyrinth components of seals operating without physical contact between the rotating and stationary parts on the shaft ends or between the individual stages—because they are attached to heavy components which have to be moved into their intended positions in other heavy components only with a small amount of clearance, just sufficient for the sealing means, and without precise guiding. A particularly serious feature in such assembly is due to the fact that the sensitive parts, for example labyrinth seals, are rigidly joined to structural components having an incomparably higher weight than the sealing parts themselves and also that they are partially disposed within the casing and are therefore not accessible to inspection even before installation is completed.

It is an object of the invention to reduce the difficulties described above and thus to facilitate assembling of the aforementioned radial flow compressors and to shorten the amount of time for such assembling operations. According to the present invention a sub-assembly for a multi-stage radial-flow compressor comprises a shaft having impellers mounted thereon, a low pressure end cover carrying a shaft bearing and a shaft seal, a high pressure end cover carrying a shaft bearing and a shaft seal, and flow deflecting elements between the two end covers, the end covers and the flow-deflecting elements being clamped up tight together, the reaction to the clamping compression being taken by tension in the shaft. Such a sub-asembly may be produced as a single unit outside the machine casing—preferably with the aid of a jig. The individual parts, in particular the stationary and moving parts of the shaft seals are fixed and secured in

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their relative positions by means of the shaft. The sub-assembly may therefore be transported easily and without risk over short and long distances, independently of the casing. The sub-assembly may also be inserted without difficulty from the low-pressure side into a pressure-tight compressor casing, constructed in cup manner, so that the high-pressure cover bears on an internal flange at one end of the casing while forming an autoclave-type seal and the low-pressure cover bears on the oppositely disposed end of the casing while forming a flange seal. After insertion of the sub-assembly into the casing and mounting of the low-pressure cover on the casing it is possible for the parts employed for stressing the sub-assembly from the shaft to be removed so that the machine may be made available for the operation for which it is intended.

To enable the stationary parts of the sub-assembly to be sealed in pressure-tight manner relative to the casing it is possible for various seals to be provided on the sub-assembly prior to the insertion thereof into the casing. For example the high-pressure end cover may have a sealing surface facing axially and away from the low-pressure cover and arranged to engage an inwardly directed shoulder in a compressor ring. Also the low-pressure cover may have a radially projecting flange having a sealing surface facing axially and towards the high-pressure cover and arranged to engage an end surface on a compressor casing. In the case of either of these pairs of surfaces, one of the surfaces may carry a sealing ring to contact the other surface of the pair. In addition, the outer circumferential surface of the sub-assembly, within the length containing the flow deflecting elements, may be formed with a seal arranged to co-operate with an internal surface on a compressor casing.

Each of at least some of the flow-deflecting elements may be divided in an axial plane, the two halves being held together by bolts extending between the two halves, the heads of the bolts preferably being sunk in pockets in the elements.

Preferably the sub-assembly includes a number of diffuser rings, each of which is located between two adjacent flow-deflecting elements. The diffuser rings may space the adjacent flow-deflecting elements apart but preferably each diffuser ring is received in a recess in a flow-deflecting element.

The flow-deflecting elements may themselves be combined together to form one or more compound components. For example, at least some of the flow-deflecting elements may be divided in an axial plane, the similar halves of the adjacent flow elements being rigidly connected to one another to form two components. Thus, during assembly and after the impellers are positioned on the shaft, the two components constituting the flow-deflecting elements may be offered up to the shaft from opposite sides of the shaft.

In order to clamp up the sub-assembly, there may be at each end of the sub-assembly a spacer ring positioned between an abutment on the shaft and the adjacent end cover and constructed to locate the end cover relative to the shaft. One or both abutments may be constituted by a nut threaded onto the shaft.

The invention may be carried into practice in various ways but one particular multi-stage radial flow compressor will now be described by way of example with reference to the accompanying drawing which is a longitudinal section of the compressor.

The impellers 2 to 7 of six successive compressor stages are mounted on a shaft 1. These impellers may be forced, shrunk or keyed on to the shaft. Flow deflecting elements 8 to 13 are disposed upstream of, between and downstream of the impellers, each being centred by means of a shoulder 14 relative to an adjacent element. At the positions 15 the flow deflecting elements are provided with sealing elements having labyrinth ribs, each element being located opposite a corresponding seal surface of an impeller, thus sealing adjacent chambers of successive pressure stages. Diffuser rings 16 are inserted in recesses in the flow deflecting elements 8 to 12 to ensure low-loss conversion of the kinetic energy into thrust energy. The diffuser rings and the last flow deflecting part 13 are provided with guide blading 17 which suitably controls the circumferential component of the deflected flow. Each of the deflecting elements 8 to 13 is axially divided into two segments which are pulled together by means of screws 18 to form a full ring. The heads of the screws are sunk in pockets in the segments. The low-pressure cover 19 at one end receives the stack of deflecting elements 8 to 13 in centring means 20 and surrounds a shaft-seal 21, a journal bearing 22 and a thrust bearing 23 in a central recess. All parts inserted into the recess together with an annular cover 24 are tightened against the cover 19 by screw fastenings 25 and 26. The high-pressure cover 27 at the other end likewise accommodates a high-pressure shaft seal 28 and a journal bearing 29 in a central recess. Screw fastening means 30 draw these elements against the cover. This cover also receives the stack of flow deflecting elements 8 to 13 by means of a centring surface 55.

At the low pressure end of the shaft 1 there is one component 31 of a shaft coupling, this component being secured on a conical part of the shaft by means of a nut

screwed on to the threaded end 33 of the shaft. There is a similar component 32 of another shaft coupling screwed on the high pressure end of the shaft by a nut screwed on the threaded end 34. The aforementioned screw-threaded ends are additionally provided for pulling together and retaining together the individual sub-assembly parts 2 to 13, 16, 19, 21 to 23, 24, 28 and 29. To this end supporting spacer rings 35, 36 respectively are centrally mounted on the two covers 19 and 27 and may be clamped up by means of the nuts 37 and 38 against the covers 19 and 27 so that the thrust bearing unit is load-relieved and the clearance 39 between the last flow deflecting element 13 and the high-pressure cover 27 disappears. It may be seen that all parts in the sub-assembly clamped together in the manner described are positively held against radial movement relative to the shaft by the journal bearings 22 and 29 and by the centring shoulders 14 and the centring surfaces 20 and 55. In particular, the sensitive sealing elements 15 in the flow deflecting parts 8 to 13 are thus prevented from bearing on the mating surfaces of the impellers 2 to 7.

A sub-assembly clamped up in this manner may be transported over any distance without risk of damage. Moreover, assembling may be performed conveniently and in unrestricted conditions outside the casing, for example on an appropriate jig which is easily accessible from all sides so that the risk of damage to the seals is also minimised during the assembling operation.

Screw-threaded rods 40 may be tightened during assembly of the sub-assembly for the axial retention of the flow deflecting elements 8 to 13 on the low-pressure cover and subsequently during operation. Also during the assembly operation a seal 41 may be inserted into the first flow deflecting element 8, for the purpose of sealing the high-pressure chamber of the compressor relative to the low-pressure chamber in subsequent operation. Seals may also be fitted to the high-pressure cover. For example a seal 42 may be inserted into the axial register surface and a seal 43 into the radial register surface 46 of the high-pressure cover 27.

The clamped-up sub-assembly may be inserted into a suitable casing 44. For this purpose, the sub-assembly is provided on its circumference with a plurality of rollers 45 to enable the sub-assembly to be guided until the centring surface 46 is inserted into the appropriate mating centring surface of the casing on the internal wall thereof. Finally, chamfered zones 47 and 48 provide the last guiding action in order to finally guide the high-pressure end of the sub-assembly into the centring surface 46 in the high-pressure end of the casing. At the same time a centring surface 49 guides the low-pressure end of the sub-assembly in the low-pressure end of the casing. The external flange on the low-pressure cover 19 of the sub-assembly will then bear on the end 50 of the casing and may be tightened by cover screws 51. At this stage the high-pressure cover 27 is still spaced a slight distance from an internal flange 52 at the high-pressure end of the casing 44. After slackening the nut 38 the cover 27 may be pulled by means of lugs 53 against the surface 54 of the internal flange 52 on the casing 44, this surface functioning as an autoclave-type seal. The compressor is thus ready for operation and the nuts 37 and 38 as well as the spacer rings 35 and 36 may be removed.

In an alternative construction, the rods 40 do not extend through the end cover 19 but only connect the similar halves of the flow deflecting elements 8 to 13 to produce two compound components. Each of these can be assembled away from the shaft and, after the impellers have been positioned on the shaft, can be moved towards the shaft in a direction radial of the shaft.

WHAT WE CLAIM IS:—

1. A sub-assembly for a multi-stage radial-flow compressor comprising a shaft having impellers mounted thereon, a low pressure end cover carrying a shaft bearing and a shaft seal, a high-pressure end cover carrying a shaft bearing and a shaft seal, and flow deflecting elements between the two end covers, the end covers and the flow-deflecting elements being clamped up tight together, the reaction to the clamping compression being taken by tension in the shaft.

2. A sub-assembly as claimed in Claim 1 in which the high-pressure end cover has a sealing surface facing axially and away from the low pressure cover and arranged to engage an inwardly directed shoulder in a compressor casing.

3. A sub-assembly as claimed in Claim 2 in which the sealing surface on the high-pressure end cover carries a sealing ring.

4. A sub-assembly as claimed in Claim 1 or Claim 2 or Claim 3 in which the low-pressure cover has a radially projecting flange having a sealing surface facing axially and towards the high-pressure cover and arranged to engage an end surface of a compressor casing.

5. A sub-assembly as claimed in any of the preceding claims in which the high-pressure cover has an outwardly facing circumferential sealing surface arranged to seal with an inwardly facing circumferential surface of a compressor casing.

6. A sub-assembly as claimed in any of

the preceding claims in which the outer circumferential surface of the sub-assembly, within the length containing the flow deflecting elements, is formed with a seal arranged to co-operate with an internal surface of a compressor casing.

7. A sub-assembly as claimed in any of the preceding claims in which each of at least some of the flow-deflecting elements is divided in an axial plane, the two halves being held together by bolts extending between the two halves.

8. A sub-assembly as claimed in any of the preceding claims which includes a number of diffuser rings each of which is located between two adjacent flow deflecting elements.

9. A sub-assembly as claimed in Claim 8 in which there is a diffuser ring between each adjacent pair of flow deflecting elements.

10. A sub-assembly as claimed in Claim 8 or Claim 9 in which each diffuser ring is received in a recess in a flow deflecting element.

11. A sub-assembly as claimed in any of the preceding claims in which at least parts of some of the flow deflecting elements are rigidly connected to one another to form a single component.

12. A sub-assembly as claimed in Claim 11 in which at least some of the flow deflecting elements are divided in an axial plane and the similar halves of the adjacent flow-deflecting elements are rigidly connected to one another to form two components.

13. A sub-assembly as claimed in any of the preceding claims which includes, at each end of the sub-assembly, a spacer ring positioned between an abutment on the shaft and the adjacent end cover and constructed to locate the end cover relative to the shaft.

14. A sub-assembly as claimed in Claim 13 in which, at least at one end, the abutment is constituted by a nut threaded on to the shaft.

15. A multi-stage radial flow compressor comprising a sub-assembly as claimed in any of the preceding claims in combination with a compressor casing constructed to receive the sub-assembly.

16. A sub-assembly for a multi-stage radial flow compressor substantially as described herein with reference to the accompanying drawing.

17. A multi-stage radial-flow compressor comprising a sub-assembly and a casing, both substantially as described herein with reference to the accompanying drawing.

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1309716 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*